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DEFORMATION HISTORY OF THE BLACK BAY FAULT AND ASSOCIATED MINERALIZATION, NORTHWEST TERRITORIES

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Background

The Black Bay Fault (BBF) is a major northeast- southwest-trending crustal feature transecting the South Rae Province of the Canadian Shield, separating the Ena (Zemlack) and McCann domains from the Firedrake and Train, all of which have different tectonometamorphic histories (Fig. 1).Active du-ring the Paleoproterozoic, timing remains poorly constrained. In Saskatchewan (SK) where a few small scale studies have been completed, the BBF has a complicated history, which encompasses a shift from a ductile to a brittle-ductile and then finally to a brittle regime with associated uranium and rare earth element mineralization. As a part of the Geological Survey of Canada GEM2 South Rae project, and in collaboration with the Northwest Territories Geological Survey, the continuation of the BBF into the NWT was examined to better understand the deformation history and economic potential of the fault (Fig. 2).

D1

D1 is a rarely observed deformation event associated with sinistral ductile deformation of the BBF with a west dipping N-S to NNE-SSW-trending foliations (Fig. 3), resulting in a west side up movement. In the south and along the northern edge, D2 had a lesser impact, and steep stretching lineations have been preserved along with shallow NE plunging lineations. Sinistral indicators associated with this event are in regions with a large degree of strain heterogeneity. L-tectonites also appear to be associated with D1. Where D2 was prevalent , north-trending fabrics appear to be the remanence of D1.

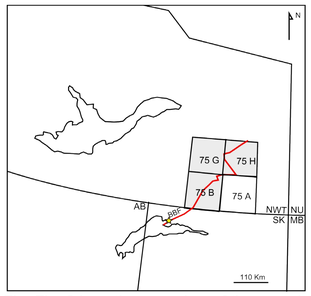


Fig. Fig. 2 Location overview of the mapping sheets and trace of the Black Bay Fault. Uranium City marked in yellow

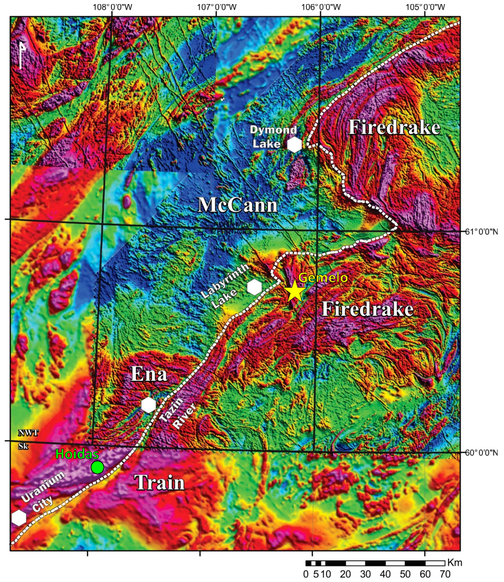
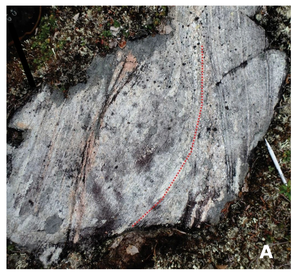
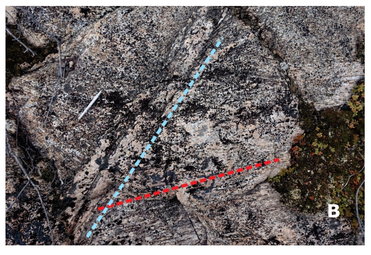


Fig. 1 Aeromagnetic survey illustrating the trace of the Black Bay Fault and the different domains which it separates along with the Hoidas and Gemelo REE showings. Aeromagnetic data from Kiss and Coyle (2012) Open files 7124-7133





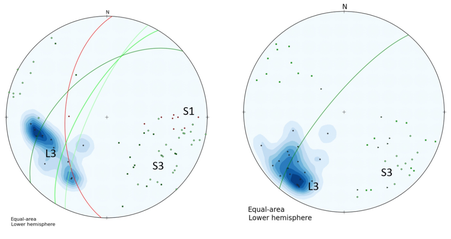


Fig. 3 A) Regional fabric becoming transposed into a D1/D3 fabric; B) Tonalitic L > S with D1 fabric crosscut by the D2 fabric; C) Stereonets of poles to foliations (S1, red, and S3, green) and lineations (L) observed in the Labyrinth Lake (left) and Dymond Lake (right) areas

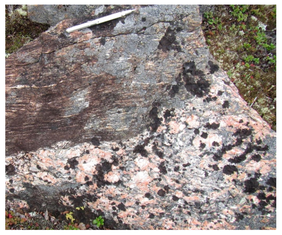


Fig. 4 Megacrystic granite of the McCann domain adjacent to the BBF, with a weak D2 fabric

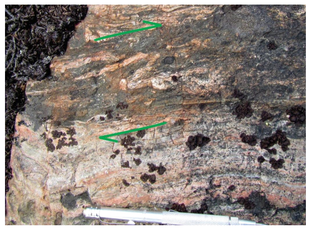


Fig. 5 Dextral kinematic indicators associated with D3.

D2

D2 is associated with the rapid change in the fault trend from NE to NW observed around Labyrinth Lake (Fig. 1) and the regional folding of lithological units. Shallowly-plunging NW stre- tching lineations (Fig. 6) are associated with a steeply SW-dipping foliation (Fig. 4) along with rare sinistral kinematic indicators. In the Firedrake, mafic xenoliths appear to have better preserved the D2 fabric compared to the hosting augen and straight gneiss which commonly contains an overprinting D3 fabric.

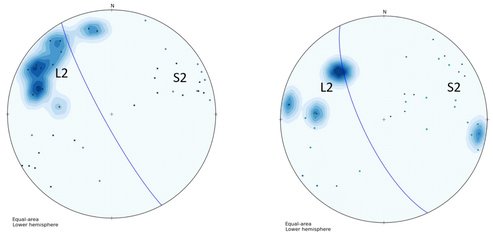


Fig. 6 Stereonets of the of poles to foliations (S2) and NW lineations (L2) of the Dymond Lake area (left) and Labyrinth Lake area (right).

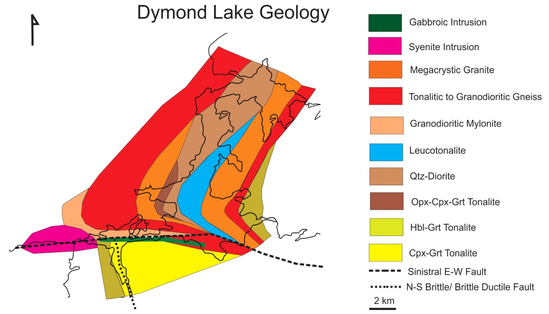


Fig. 7 Geological Map of the Dymond Lake Are. Return of large brittle-ductile to brittle deformation

D3

The D3 is a commonly observed dextral transpressional ductile deformation event, overprinting the D1 and D2 fabric (Fig. 3).Steep west-dipping NE-SW-trending foliation with associated shallowly SW-plunging lineations along with dextral kinematic indicators are commonly observed (Fig. 5).While the D3 fabric is widespread, the event does not appear to have had a large impact on the fault orientation.

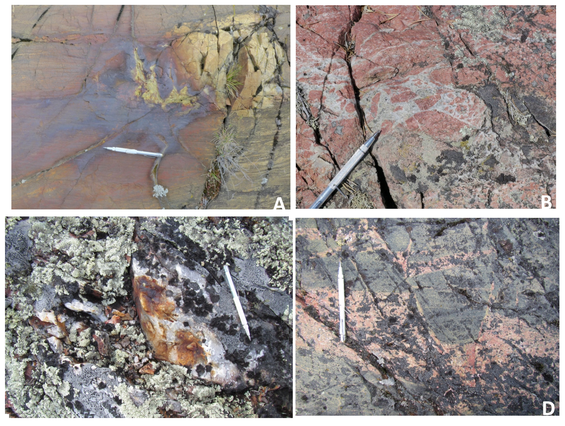


Fig. 8 A) Sulphide and uranium mineralization around Uranium City. B) Quartz filled breccia near Uranium City. C) Reemergence of sulphides mineralization around Dymond Lake. D) Brittle deformation around Dymond Lake.

Differential uplift and brittle deformation

Late stage brittle and brittle-ductile deformation, D4, is readily observed around Uranium City with sulphides and uranium mineralization often observed (Fig 8). A dextral component parallel to the fault trace, with a conjugate set of E-W-trending sinistral faults. The uranium mineralization is observed to extend north to the Tazin river area with counts per second above 12000 recorded, but further northward the brittle deformation and associated mineralization disappears. Straight and augen gneiss instead become more common, likely due to differential uplift of the fault. Where the fault returns to a NE-SW trend around Dymond Lake, a reemergence of the brittle deformation is observed (Fig. 7) along with sulphides and potentialuranium mineralization.

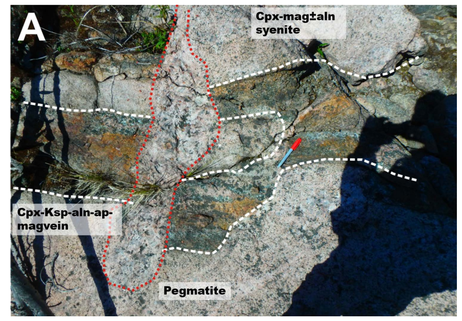


Fig. 9 REE mineralized vein at Gemelo with assay results. Vein is trending parallel to the S3 fabric.

In the northeast portion of the BBF andinto the NWT, rare earth element (REE) mineralization was recognized E of Laby-rinth Lake, at the Gemelo showing. The showing is hosted by a clinopyroxene-syenite and the mineralization comprises clino-pyroxene-magnetite-hyalophane-allanite segregations and veins with REE concentrations of >0.97% (Ce= 4750 ppm + La= 2270 ppm + Nd= 2230 ppm) (Fig. 9) . A similar mineralization style has been recorded in northern SK, along the BBF in the hydrothermal vein-breccia hosted Hoidas deposit (Fig. 10). Thus, the Gemelo showing may represent the magmatic and deeper crustal component of a Hoidas-like hydrothermal REE system, mimicking the differential uplift observed along the fault. Mineralization at the Gemelo showing, does not appear to be as strongly structurally controlled as in Hoidas, but mineralized structures are primarily aligned with the D3 fabric. Recent U-Pb dating studies suggest that the REE ore at both systems is contemporaneous.

Fig. 10. Comparison of the REE Gemelo showing vs Hoidas deposit, both with cpx-ksp-mag-aln mineralization and alkali magmatism

Summary

Overall the Black Bay Fault experience four main generation of deformation, D1-4. Beginning with sinistral west side up motion, D1 produced the majority of exhumation of the BBF. D2 produced large scale folding of the Black Bay Fault resulting in the variation of the fault trace. D3 marks the onset of dextral west-side up transpression. D4 produced brittle to brittle-ductile deformation, better preserved in the south due to differential uplift along the fault. This study shows that REE mineralization along the BBF is not restricted to northern SK, and instead, similar mineralization assemblages are observed ~100 km NE into the NWT,at the Gemelo showing. Thus, the historically underestimated economic potential of the NE portion of the BBF has to be re-evaluated.

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